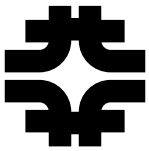

Fermi National Accelerator Laboratory

FERMILAB-Conf-95/356

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November 1995

Proceedings of the *Computing in High Energy Physics 1995 (CHEP '95)*,
Rio de Janeiro, Brazil, September 18-22, 1995

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy

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THE FERMILAB ISDN PILOT PROJECT: EXPERIENCES AND FUTURE PLANS[1]

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Fully operational in June of 1994, the Fermilab ISDN Pilot Project was started to gain insight into the costs and benefits of providing ISDN service to the homes of Fermilab researchers. Fourteen users were chosen from throughout Fermilab, but the number of Fermilab-employed spouses pushed the total user count to 20. Each home was equipped with a basic rate ISDN (BRI) line, a BRI Ethernet half-bridge, and an NT-1. An inter-departmental team coordinated the project. Usage at each home was tracked and frequent surveys were attempted. Lessons learned include: working with Ameritech can be difficult; careful monitoring is essential; and configuration of home computing equipment is very time consuming. Plans include moving entirely to primary rate ISDN hubs, support for different home ISDN equipment and better usage and performance tracking.

1. EARLY EXPERIMENTATION

In 1991 the HEP Network Resource Center (HEPNRC), then known as National HEPnet Management, began experimenting with basic rate ISDN (BRI) for work-at-home use. At the same time, the Fermilab Telecommunications Group began experimenting with BRI for on-site access to the IBM 4381. Both experiments used terminal adapters, with serial ports limited to 38.4 Kbps. Although both systems worked, the unimpressive speed gains meant the systems were not adopted for production use.

For work-at-home access, there was an even greater stumbling block. Ameritech (the local phone service provider in the Chicago area) had just begun offering ISDN. The charges were based on the existing Switched-56 service offering. A BRI line cost US$100 per month and usage was charged at US$0.10 per minute. This made the cost of ISDN unacceptable for casual work-at-home use. Still, both Fermilab Telecom and HEPNRC continued tracking ISDN equipment development and Ameritech pricing.

In early 1992, ISDN bridges became available from Combinet and Digiboard. After extensive talks with both companies, HEPNRC chose to deal with Combinet. After a site visit to Combinet's headquarters and manufacturing, HEPNRC purchased several Combinet bridges and did a single home ISDN installation, in Chicago's Lincoln Park neighborhood. Later in 1992, another user was added, this time in the Chicago suburb of Downer's Grove. These installations provided a wealth of experience in both ISDN equipment and the process for dealing with Ameritech. Also in 1992, Ameritech lowered their tariff on BRI to about US$40/month and set the usage charges equal to that of a normal voice call.

In 1993, with Fermilab funding, HEPNRC produced a report detailing an expansion of the existing experiment's architecture and proposing a trial of ISDN on a broader scale with more typical users. In addition, HEPNRC did a study of the ISDN bridging

[1] Supported by the US Department of Energy under contract number DE-AC02-76CH03000.

equipment available and once again chose Combinet. In late 1993 the project was approved. In early 1994, the 14-person participant list was complete. Two-employee household pushed the total participant count to 20.

2. THE FERMILAB ISDN PILOT PROJECT

Figure 1 shows the architecture of the pilot project. Each of the 14 remote sites had a Combinet CB-400 and a Nortel NT-1 installed. Each user was expected to already have an Ethernet-equipped computer or X terminal at home. In the Feynman Computer Center, on the Fermilab campus, eight CB-400s and eight NT-1s were installed in a rack. A hunt group was set up such that incoming calls were routed to an idle bridge.

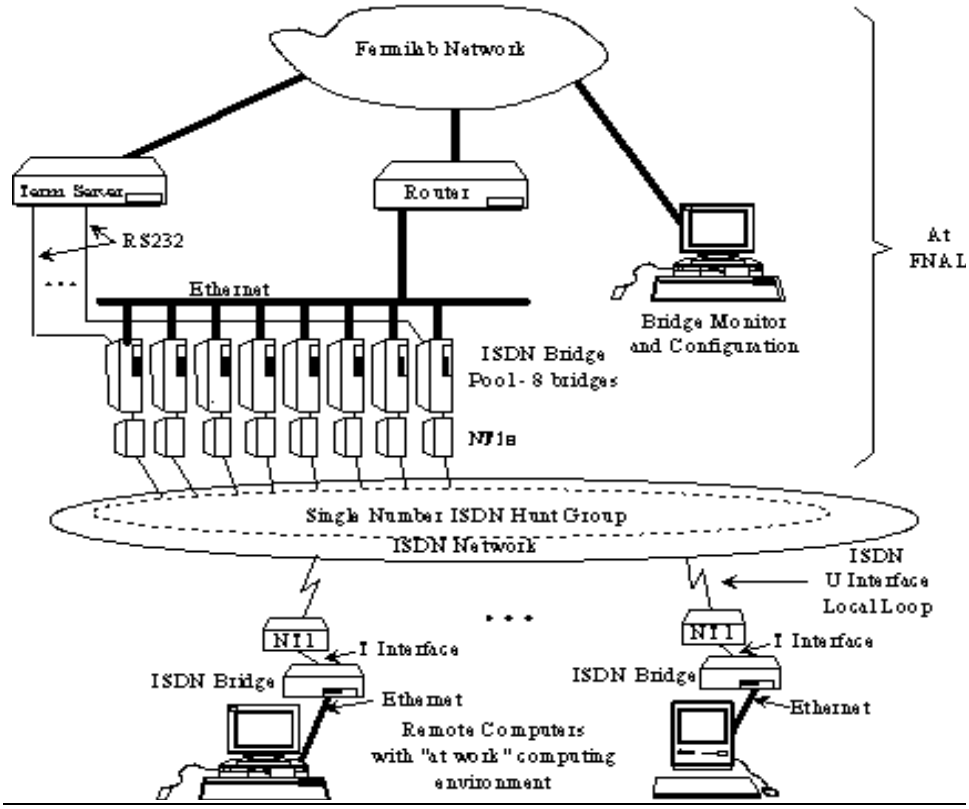

Figure 1: BRI Remote Access Architecture

The home bridge initiates a call to the central site when it receives packets to be bridged. When the call is received by a central site bridge, it verifies the password delivered, hangs up, then calls the home site back. Callback has two advantages. First, it is more secure, since the bridges can be set up to call only certain numbers. Second, it is cheaper. Fermilab gets approximately 50% discount on ISDN calls due to its large

amount of voice calls. The calls stay up until the central site sees no traffic from the home site for 20 minutes, at which time it drops the call. The central site bridge monitors the bandwidth used and when it is over 40 Kbps for ten seconds, the central site bridge places a call on the second B channel to the home bridge. The second channel is kept up until no packets are sent across it for five minutes.

3. EXPERIENCES

3.1 ISDN Pilot Project Team

Since the planning and operation of the ISDN Pilot Project crossed several Lab organizations, a team was formed with staff from the HEP Network Resource Center, the Fermilab data communications group and the Fermilab telecommunications group. The team shared a common e-mail alias and met frequently to plan and implement. The close working relationship among different groups was a very beneficial side-effect of the pilot project.

3.2 ISDN Line Installation

All 14 home sites were served by Ameritech, the company that also provides Centrex phone service to Fermilab. Since all the home lines were considered business lines and directly billed to the Lab, the Fermilab telecom group placed the orders as they do any Ameritech service to the Lab. After placing the orders, Ameritech gave written assurance to Fermilab that all the lines could be installed with a one week notice of the date desired. HEPNRC and Fermilab telecom generated a schedule to install all but one line in a two week period. Unfortunately, Ameritech was unable to meet the installation schedule.

After Ameritech missed the second scheduled installation, all further installations were put on hold by Fermilab. A two-stage installation was devised. First, Ameritech would work to install the line to the outside of the residence. This often took several weeks. Second, an Ameritech installer would meet with an ISDN Pilot Project team member at the home. The pilot project participant or a family member was also required to be present. During this second visit, the Ameritech installer would do inside wiring and install a RJ-11 jack for the ISDN service. This proved to work fairly well, although Ameritech was unable to meet Fermilab's request to have the same installer on all installations.

3.3 Home Equipment Installation and Configuration

After the wiring and jack were installed, a pilot project team member then connected the Combinet bridge and configured it for the new line. After successful test calls to the Lab, the team members would then connect the bridge to the home computer via Ethernet wiring. Usually this went smoothly, but a bug in the Combinet software caused the bridge to not establish sync with the NT-1 when connected to BRI lines served by some AT&T 5ESS switches. This problem was eventually solved by a new version of bridge firmware from Combinet.

In most cases, the pilot project participant already had a computer or X terminal at home. The initial plan assumed that the pilot project participants would already have

the equipment configured for the new network connection. Instead, the pilot project team spent large amounts of time getting home machines configured, especially NCD X terminals. Many of the X terminals used were already connecting to the Lab using Xremote. The stored boot image was useless for Ethernet connections, though, since it only supported Xremote. When switched to booting across the network, the configuration information stored in EEPROMs was not available. Since NCD X terminals have over 200 configuration parameters, reconfiguration was often time consuming.

PCs were almost as difficult to configure since many different stacks were in use, but the pilot project PC users were able to do most of the reconfiguration themselves. Macintoshes, finally, were the easiest to configure since they all used MacTCP for IP connections and the same setup procedure worked each time. Appletalk reconfigured itself and required no intervention.

To minimize the time spent at a participant's home, HEPNRC set up an ISDN testbed in the HEPnet lab. The testbed consisted of a setup identical to one that a user would have installed at home. Participants were strongly encouraged to bring their equipment to the testbed before their line was installed. The advantage was twofold. First, problems could be worked out at a more leisurely pace by the participants themselves. Second, the location of the testbed in the Feynman Computing Center meant that local experts could be brought in as needed. The testbed greatly reduced the time for the final installations.

3.4 Network Monitoring

Combinet CB-400 bridges have little on-board monitoring capabilities. Once a call has terminated, a bridge clears all information associated with that call. Also, CB-400s do not support SNMP or telnet. Therefore, HEPNRC developed a program called CBRC (Combinet Bridge Remote Control). CBRC ran under SunOS and established a link to a Combinet bridge using UDP/IP and Combinet's proprietary configuration protocol. HEPNRC also developed a set of AWK and shell scripts that log into each hub bridge at 10 minute intervals. The state of the bridge was logged and used to produce detailed reports. The pilot project team reviewed the reports for abnormal activity. CBRC also allowed pilot project team to connect to a bridge at a participant's home to check or modify its configuration.

The pilot project team also planned to frequently survey the participants about their impressions of the pilot. After four questionnaires, surveys were stopped due to the low response rate. Passive monitoring and trouble reports provided the only formal view of participant's behavior. Figure 2 shows the average number of users logged in at various times of the day during 8 months of the pilot, from October. 1, 1994 to March 31, 1995. The most popular time to log in was in the evening, with 10:30 PM being the highest point. (3.09 sites, on average, were connected then.) The least popular time was early morning, with 3:50 and 4:00 AM being the lowest point. (Only 0.19 sites, on average, were connected then.)

Despite the lack of detailed user feedback, the general impression was that the participants were pleased with the service. In particular, when service interruptions occurred participants complained that it greatly reduced their productivity. Even switching back to 28.8 Kbps modems was unacceptable to most participants after they grew accustomed to the fast connect times and high bandwidth of ISDN.

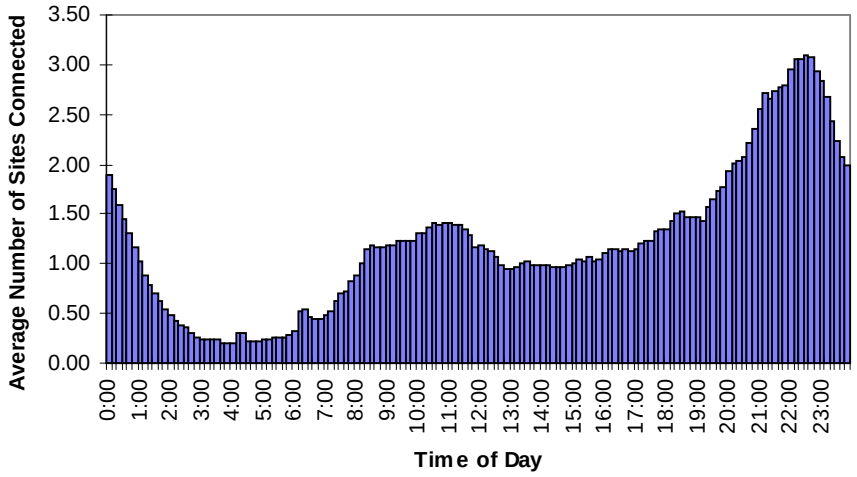

Figure 2: Average Number Connected vs. Time of Day (8/1/94 - 3/31/95)

3.5 Protocols Supported

The pilot project supported TCP/IP, DECnet and Appletalk protocols. All were transparently bridged to the home machine. Not supported were non-routable protocols such as BOOTP and MOP. Most homes used TCP/IP, although the homes with Macintoshes used Appletalk as well. Only one home used DECnet. The heavy use of TCP/IP was fortuitous, since the TCP/IP suite does not typically send status messages. Therefore, when the user stopped an application, traffic stopped as well. This allowed the link to drop because the home bridge sensed there were no packets to be sent.

Appletalk was more of a problem. Programs such as the Chooser send constant updates which will keep the link up indefinitely, even if no one is using the computer. Shutting down the Chooser and similar programs usually silenced the Macintoshes. However, some Macintosh users were told to shut their bridge off when they did not need the link. There was not enough DECnet usage to determine if there are problems with it.

3.6 Administrative Issues

The pilot project was the first time that Fermilab support was explicitly given to people working from home, although the Fermilab modem pool and casual loans of equipment for home had been used for years. One issue was financial responsibility. Because it was a pilot project, the Fermilab Computing Division agreed to pay for all bridges, BRI lines and usage charges. Each participant, or the participant's organization, was responsible for the home computing equipment. Another issue was approvals. Since such a project had never been done before, the Computing Division, the Business Services Section and the Directorate all requested to sign off on both the original plan and each individual installation. In addition, the management of the division or section where the participant worked had to okay its employee's participation.

3.7 Pilot Project Conclusion

The Fermilab pilot project had no formal conclusion. In November of 1994, the Computing Division issued a DCD Note providing some experiences and recommending the continuation of ISDN services. All participants still have service, except for one that moved and did not have service re-established. Support of the day-to-day operations of ISDN service was moved to regular datacomm and operations support.

4. PLANS

Central site support has been moved from a pool of BRI bridges to a Combinet CB-900 PRI hub that can support 23 simultaneous connections. When Combinet fully implements SNMP support on the CB-900, it will be managed along with the current Fermilab bridge and router infrastructure. This will also get rid of the home-brew tracking system and integrate remote usage tracking with the current LAN traffic monitoring.

The ISDN remote-access industry is standardizing on multi-link PPP (MLP) and new Combinet bridges provide MLP support. When Combinet implements MLP on the CB-900, a wide variety of home bridges and adapters can be supported. Fermilab will do careful evaluations before allowing new equipment into the mix.

Currently, connections are established and dropped based solely on the status of the home bridge. With the integration of ISDN controls into products such as Windows NT, it may be possible to give the remote user more control over when connections are made and broken. In addition, there is currently no way for a user to connect to a home machine while working at Fermilab. If files are stored on the home machine, they are inaccessible until the user goes home and starts sending packets to Fermilab. Through the use of Ethernet or IP tables listing each user's equipment and phone number, it is possible to establish demand links based on central site traffic.

Home ISDN equipment, service and monthly charges are now the responsibility of the user's organization. The cost of equipment and personnel for central site support are provided by the Computing Division; the intention is to make home ISDN service like any other resource on which managers may spend their money.